(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 270 804 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
01.11.2023 Bulletin 2023/44

(21) Application number: **22170024.8**

(22) Date of filing: **26.04.2022**

(51) International Patent Classification (IPC):
H04B 5/00 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
H04B 5/0031; H04B 5/0062

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **STMicroelectronics razvoj polprevodnikov d.o.o.
1000 Ljubljana (SI)**

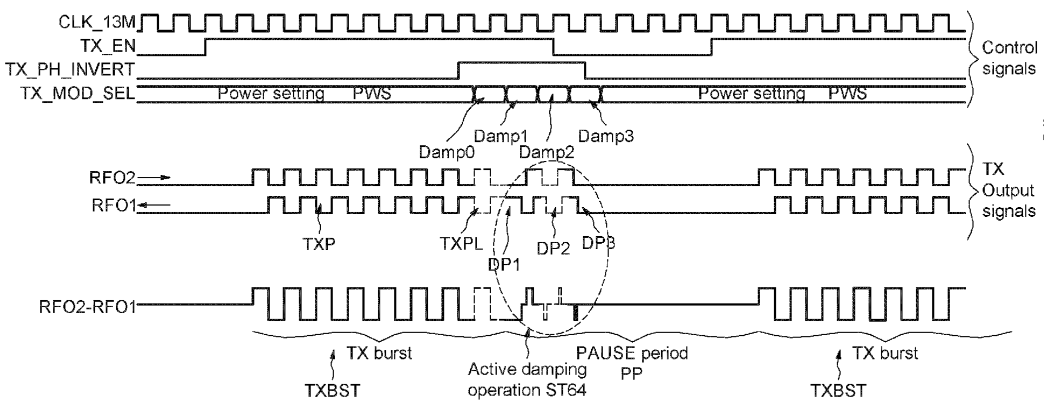
(72) Inventor: **KOROSAK., Ziga
4281 MOJSTRANA (SI)**

(74) Representative: **Casalonga
Casalonga & Partners
Bayerstraße 71/73
80335 München (DE)**

(54) ACTIVE DAMPING AND POWER CONTROL IN NFC ACTIVE LOAD MODULATION

(57) Method for managing a signal transmission emitted by a wireless transponder (TG) to a reader (RD), said transmission using an active load modulation and being based on transmitted bursts (TXBST) separated by pause periods (PP), each transmitted burst (TXBST) including transmitted pulses (TXP), said method comprising
-performing an active damping operation (ST64) at the end of said transmitted bursts in the beginning of the pause periods, said active damping operation comprising transmitting a number of additional pulses (DPI, DP2, DP3) having a phase opposite to the phase of said transmitted pulses (TXP), and
-controlling the transmitted pulses power (PWS), the additional pulses power (Dampi), the number of additional pulses (N) based on a distance (D) between the reader and the wireless transponder and on reference values of the transmitted pulses power, the additional pulses power, and the number respectively associated with reference distances.

FIG.7



EP 4 270 804 A1

Description

[0001] Embodiments of the present disclosure relate to wireless or contactless communication, in particular a Near Field Communication (NFC), between a reader and a transponder, for example complying with RFID ("Radio Frequency Identification") and NFC ("Near Field Communication") standards, and more particularly to the damping and power control in NFC active load modulation.

[0002] In wireless systems, for example RFID or NFC systems, which use magnetic coupling, two different types of devices usually participate.

[0003] A reader is a device that transmits a magnetic field which carries data as well as power which is used by the other device (the transponder or tag) in the communication.

[0004] The other device (the tag) is usually passive and is thus entirely powered by the reader's magnetic field.

[0005] The tag usually communicates by load modulation of reader's magnetic field.

[0006] Alternatively, the tag can use active transmission to actively load modulate the reader's field.

[0007] Active load modulation (ALM) is well known by the man skilled in the art.

[0008] Examples of such an active transmission using ALM can be found in particular in WO2013002736 A1 or in EP2824612A1.

[0009] Active transmit tag or transponder, using ALM, need to synchronize the frequency and phase of their internal frequency source to the frequency and phase of carrier signal emitted by the reader.

[0010] This is usually done using a phase locked loop (PLL).

[0011] The PLL locks to the signal received by the tag, which comes from the reader's magnetic field.

[0012] When the tag's own transmission starts, its own signal is much larger than the reader's signal.

[0013] Therefore, it becomes difficult to recognize the reader's signal to keep the PLL locked.

[0014] In conventional applications the PLL is unlocked during this time.

[0015] However, with long transmission frames it becomes difficult to keep the PLL's phase constant in an unlocked state and so it is preferable to resynchronize the PLL to reader's signal during short transmission pauses.

[0016] But, because the tag's transmission signal is much larger than the reader's signal, during a short pause the amplitude of oscillation due to tag's own transmission signal may not decease enough for oscillation due to reader's signal to become visible by the receiver (the tag).

[0017] Methods to dampen tag's transmission signal oscillation on the antenna during these short pauses have been proposed, in particular in EP2824612A1.

[0018] In some conditions, previously proposed solutions do not provide strong enough damping for tag's receiver to be able to see reader's signal during short transmission pauses.

[0019] Further, previously proposed solutions may require additional pins on the chip, which increases device size and cost.

[0020] There is thus a need for another more efficient solution for damping the tag's transmission signal oscillation on the antenna during these short transmission pauses.

[0021] According to an embodiment a new damping solution is proposed which can be used standalone or in combination of the previously proposed solutions.

[0022] According to an embodiment a method of active damping the antenna oscillation due to the transmitted tag's signal is proposed by transmitting with the opposite phase during the start of pause period.

[0023] In order to not induce oscillation of opposite phase on the antenna with the active damping operation, power output is advantageously controlled.

[0024] According to an embodiment, a digital-to time converter based phase modulator may be used to both perform the 180° phase change operation and perform power control by using outphasing (differential phase modulation).

[0025] Outphasing can also be used during normal transmission period to control transmitted power.

[0026] In alternative implementation an envelope shape control capable regulator can be used for power control.

[0027] When single ended antennas are used, a mixer is advantageously implemented to convert outphased carriers to radio frequency (RF) pulse width modulated (PWM) signals.

[0028] The phase modulator may also perform common mode phase modulation to achieve desired angle between transmitted and received signals.

[0029] Thus according to an aspect, a method is proposed for managing a signal transmission emitted by a wireless transponder to a reader.

[0030] Said transmission uses an active load modulation and includes transmitted bursts separated by pause periods.

[0031] Each transmitted burst includes transmitted pulses.

[0032] The method according to this aspect comprises

- performing an active damping operation at the end of said transmitted bursts in the beginning of the pause periods, said active damping operation comprising transmitting a number of additional pulses (also called "damping pulses") having a phase opposite to the phase of said transmitted pulses, and
- controlling the transmitted pulses power, the additional pulses power and the number of additional pulses based on a distance between the reader and the wireless transponder and on reference values of the transmitted pulses power, the additional pulses power, and the number respectively associated with

reference distances.

[0033] The man skilled in the art will be able to determine an appropriate number of additional pulses depending on the application, an in particular on the characteristics of the antenna structure and matching circuit of the tag.

[0034] Preferably, but in a non-limitative way, the number of additional pulses is equal or smaller than three.

[0035] This number is not necessarily an integer.

[0036] According to an embodiment, controlling the transmitted pulses power, the additional pulses power, and the number of additional pulses comprises determining said distance between the tag and the reader and selecting the reference values associated to the closest reference distance to the determined distance.

[0037] For example, determining said distance may comprise measuring at the wireless transponder this distance by using the well-known Received Signal Strength Indicator (RSSI), i.e. the strength of the signal received at the wireless transponder.

[0038] Generally speaking, said wireless transponder is of a given model of wireless transponder.

[0039] And, according to an embodiment, the method further comprises elaborating said reference values of the transmitted pulses power, the additional pulses power and the number of damping pulses for a reference wireless transponder of said given model during a development phase of said reference wireless transponder, for example during a test phase of the reference wireless transponder in laboratory after its fabrication.

[0040] Said elaborating comprises for example determining said reference values for each reference distance of a set of references distances by using a performance criterion.

[0041] More particularly, for a given reference distance, determining the associated reference values comprises selecting the reference values leading to the fulfilment of the performance criterion.

[0042] More precisely and according to an embodiment, the reference wireless transponder has a phase locked loop, the signal transmission includes frames transmission and the fulfilment of the performance criterion comprises an amplitude of the phase drift of the phase locked loop with respect to its initial phase during the transmission of a whole frame, being as low as possible, for example smaller than a threshold.

[0043] Although other possibilities can be used, controlling the transmitted pulses power, the additional pulses power comprises advantageously performing an outphasing of two phase modulated signals.

[0044] It is also possible, in particular with a single ended architecture of the transponder's antenna, that controlling the transmitted pulses power, the additional pulses power further comprises performing a mixing operation of both outphased signals to obtain pulse width modulated signals.

[0045] It is also possible to combine the above defined active damping with a passive damping, in particular a passive damping of the prior art.

[0046] Thus, according to an embodiment, the method further comprises performing a passive damping operation at the end of said transmitted bursts in the beginning of the pause periods, said passive damping operation comprising activating a connection of a resistive circuit to the antenna of the wireless transponder.

[0047] According to another aspect, a wireless transponder is proposed, comprising

- transmission means configured to transmit an active load modulated signal to a reader, said modulated signal including transmitted bursts separated by pause periods, each transmitted burst including transmitted pulses,
- active damping means configured to transmit at the end of said transmitted bursts in the beginning of the pause periods, a number of additional pulses having a phase opposite to the phase of said transmitted pulses, and
- control means configured to control the transmitted pulses power, the additional pulses power and the number of additional pulses based on a distance between the reader and the wireless transponder and on reference values of the transmitted pulses power, the additional pulses power, and the number respectively associated with reference distances.

[0048] According to an embodiment, the number of additional pulses is equal or smaller than three.

[0049] According to an embodiment the wireless transponder further comprises measurement means configured to determine the distance between the wireless transponder and the reader, and the control means are configured to control the transmitted pulses power, the additional pulses power, the number of additional pulses, by selecting for the determined distance, the reference values associated to the closest reference distance to the determined distance.

[0050] According to an embodiment, said wireless transponder is of a given model of wireless transponder, and the reference values of the transmitted pulses power, the additional pulses power and the number of additional pulses for a reference wireless transponder of said given model are elaborated during a development phase of said reference wireless transponder, for each reference distance of a set of references distances by using the fulfilment of a performance criterion.

[0051] According to an embodiment, the reference wireless transponder has a phase locked loop, and the fulfilment of the performance criterion comprises an amplitude of the phase drift of the phase locked loop with respect to its initial phase during the transmission of a whole frame, being smaller than a threshold.

[0052] According to an embodiment, the control means comprises a digital-to-time converter based phase modulator configured to control the transmitted pulses power and the additional pulses power by performing an outphasing of two phase modulated signals.

[0053] According to an embodiment, the control means further comprises a mixing circuit configured to perform a mixing operation of both outphased signals to obtain pulse width modulated signals.

[0054] According to an embodiment, the wireless transponder further comprises a controllable resistive circuit connected to the antenna of the wireless transponder and configured to perform a passive damping operation at the end of said transmitted bursts in the beginning of the pause periods.

[0055] According to an embodiment, the wireless transponder is configured to perform wireless communications according to at least one of the following standards: ISO14443 TypeA; ISO14443 TypeB; ISO15693.

[0056] Other features and advantages of the present invention will appear when examining the following detailed description, only providing non-limiting example of embodiments, with reference to the appended drawings in which:

Figure 1 to 12 illustrate particular embodiments of the invention.

[0057] Figure 1 illustrates a wireless transponder or tag TG including an integrated circuit IC comprising transmission means TX and receiving means RX, for example configured to perform wireless communications with a reader RD according to ISO14443 TypeA standard, and/or ISO14443 TypeB standard, and/or ISO15693 standard.

[0058] The tag TG uses active load modulation -ALM- for transmitting data to the reader RD.

[0059] The transmission means TX is configured to transmit frames including ALM carrier bursts to the reader RD through an antenna ANT.

[0060] Said antenna comprises in particular an inductive element L_{ANT}.

[0061] The tag TG comprises also a conventional impedance matching and filtering circuit CIMPFLT1 connected between the antenna ANT and the terminals TTX1, TTX2, TRX1, TRX2 of the transmission means and the reception means.

[0062] The impedance matching and filtering circuit CIMPFLT1 comprises here capacitors C_P, C_{FILT1}, CFILT2, C_{S1}, Cs2, C_{RX20}, C_{RX10}, C_{RX1}, C_{RX2}, inductive elements L_{FILT1}, L_{FILT2} and resistors R_{RX3}, R_{RX4}, R_{ANT1}, RANT2.

[0063] The receiving means RX comprises conventionally a demodulation circuit coupled to a decoding circuit for receiving data from the reader RD through antenna ANT.

[0064] The decoding circuit provides data to a processing unit MC, for example a processor, which provides also data to be sent to the reader.

[0065] The data may be for example application data of a NFC (Near Field Communication) application such as transaction, payment, ...

[0066] A conventional circuit extracts from the signal received by the tag a clock signal having a frequency equal to the reader carrier frequency, which is for example equal to 13,56 MHz in ISO/IEC 14443.

[0067] The transmission means comprises conventional encoding means configured to perform here for example a Binary Phase Shift Keying (BPSK) data encoding.

[0068] The encoding means provides to modulating means (belonging to the transmission means) a data modulating signal using a subcarrier (here a 847,5 KHz subcarrier).

[0069] As illustrated in figure 2, one bit period of a bit b to be transmitted to the reader contains 8 subcarrier periods T1.

[0070] The logical value of the bit b depends on the state high or low of the beginning of the bit period. For example, a bit period beginning with a high state and finishing with a low state may be considered as being a logical "1" whereas a bit period beginning with a low state and finishing with a high state may be considered as being a logical "0". Of course, this convention could be inverted.

[0071] Figure 3 illustrates an example of a series of bits 1, 0, 1, 0 contained in the data modulating signal SD provided by the encoding means.

[0072] The modulation means receive the data modulating signal SD as well as an ALM clock signal advantageously provided by a conventional digital phase locked loop (DPLL).

[0073] The modulation means are configured to perform a subcarrier modulation with said data encoding for generating a signal STX to antenna ANT.

[0074] This signal STX comprises, as illustrated in figure 4, bursts BST of ALM carrier SC (said ALM carrier SC having a frequency equal here to 13,56 MHz).

[0075] Two consecutive bursts BST are separated by a gap or pause period wherein no signal is transmitted from the transponder to the reader.

[0076] Each half period of the subcarrier period T1 during which there is a signal transmission contains 8 periods of the carrier signal SC.

[0077] The signal STX and the corresponding signal STXA at the antenna of the tag are illustrated in figure 5. The signal SRD corresponds to the oscillation of the reader carrier signal present on the antenna of the tag TG.

[0078] As illustrated in this figure 5, each generation of ALM carrier burst BST produces after said generation, signal oscillation OSC at the antenna which naturally decays due to the quality factor of the antenna.

[0079] However, because the tag's transmission signal STXA is much larger than the oscillation of the reader's signal SRD, during a short pause, the amplitude of oscillation OSC due to tag's own transmission signal STXA may not decease enough for oscillation due to reader's signal SRD to become visible by the tag.

[0080] Thus, generally speaking, an active damping the antenna oscillation is proposed by transmitting with the opposite phase of antenna oscillation OSC during the start of pause period, i.e. by transmitting pulses with reverse angle compared to antenna oscillation angle to damp the antenna oscillations.

[0081] More precisely, as indicated above, bursts BST of ALM carrier SC are transmitted by the tag, separated by gaps or pause periods.

[0082] Those bursts of ALM carrier SC are based on transmission (generation) of bursts of pulses, called transmitted pulses. Those bursts of transmitted pulses are separated by the pause periods.

[0083] And the active damping is performed at the end of said transmitted bursts in the beginning of the pause periods, and comprises, generally speaking, transmitting a number of additional pulses (also called damping pulses) having a phase opposite to the phase of said transmitted pulses.

[0084] Further, in order to avoid as much as possible inducing oscillation of opposite phase on the tag's antenna, the output power of signal delivered during this active damping, i.e. the additional pulses power, is advantageously controlled.

[0085] An example of a method according to the invention is more particularly disclosed on figure 6.

[0086] In step ST60, the bursts of pulses are transmitted and are separated by pause periods.

[0087] In step ST61, the distance D between the reader RD and the tag TG is measured by measurement means MMS.

[0088] Those measurement means MMS, incorporated for example in the reception means RX, are conventional means configured to measure the distance D by using for example the RSSI of the signal received by the tag on its antenna.

[0089] Then, as it is well-known by the man skilled in the art, a mathematical formula permits to determine the distance D from the RSSI.

[0090] The tag TG comprises also a memory MM storing a look-up table LUT.

[0091] This look-up table LUT includes reference values of the transmitted pulses power PWS, reference values of the additional pulses power Dampi, the number N of damping pulses, and, all these reference values as well as the number N are associated with reference distances Dref between the reader and the tag.

[0092] The way of how those reference values associated with the reference distances are determined will be explained more in detail thereafter.

[0093] After the distance D has been determined by the measurement means MMS in step ST61, the reference distance Dref closest to distance D is determined in step ST62.

[0094] And, with this determined reference distance Dref, the transmitted pulse power PWS, the damping pulse power Dampi and the number of damping pulses N, associated to this determined reference distance Dref, are extracted from memory MM.

[0095] In step ST64, the above-mentioned active damping operation is performed by active damping means ACTDM.

[0096] More precisely, as indicated above, this active damping operation comprises a transmission of the N damping pulses in the beginning of pause periods.

[0097] And, in step ST65, control means CTRLM perform a power control of the transmitted pulses by using the power setting PWS and a control of the damping pulse power by using the extracted value Dampi.

[0098] The control means CTRLM define also the number N of damping pulses based on the number extracted from the loop up table LUT.

[0099] Depending on the application, it could be also useful to perform, for example simultaneously with the active damping operation, a passive damping operation ST66.

[0100] This passive damping operation, performed by passive damping means PASDM, will be explained more in detail thereafter.

[0101] We refer now more particularly to figure 7 which illustrates diagrammatically a chronogram showing the active dumping operation ST64.

[0102] This example shows BPSK coding example for ISO14443 type B 847.5 Kbits/s communication from the tag to the reader.

[0103] Of course, other types of coding are possible, such as the Manchester coding.

[0104] This example corresponds also to a differential AND or basic mode. As it will be explained more in detail thereafter, the tag comprises a driver stage including two drivers respectively connected to the two terminals TTX1 and TTX2. The terms differential and full differential refer purely to the driver idle state. A differential state corresponds to the same state of the two drivers while the two drivers may operate differentially during transmission. A fully differential state corresponds to the fact that the two drivers are in a differential state even when idle.

[0105] AND mode, XOR mode, 3-Phase mode, correspond to different transmission modes well-known by the man skilled in the art. For example, the man skilled in the art may refer to EP3145092A1 for the XOR mode, to US10608705B2 for the 3-phase mode and to EP2824612A1 for the AND (or Basic) mode.

[0106] All those three types of transmission modes can be used with differential or fully differential state, and are compatible with the active damping of the present invention.

[0107] The control signals are illustrated in the top part of figure 7.

[0108] More precisely, CLK_13M is a ALM clock having a frequency of 13,56MHz.

[0109] TX_EN is the control signal activating or not the transmission of the tag'signal.

[0110] TX_PH_INVERT is a logical signal triggering the phase inversion of the pulse(s).

[0111] TX_MOD_SEL is the digital control word controlling the power settings PWS and Dampi. Here, 4 possible values of Dampi are possible, Damp0, Damp1, Damp2 and Damp3.

[0112] The bottom part of figure 7 illustrates the (TX transmission) output signals.

[0113] More precisely, RFO2 is the output signal present at terminal TTX2 while RFO1 is the output signal present at terminal TTX1.

[0114] Arrows next to the references RFO1 and RFO2 show the direction of phase change.

[0115] And, RFO2-RFO1 is the difference between the two mentioned signals RFO2 and RFO1.

[0116] Reference TXBST designates the transmitted bursts including the transmitted pulses TXP. As indicated above, the transmitted bursts TXBST are separated by pause periods PP.

[0117] Reference TXPL designates the last transmitted pulse (in dotted line) of the burst TXBST.

[0118] And, as shown in this figure 7, after the last transmitted pulse TXPL, the damping pulses are transmitted in the beginning of the pause period PP.

[0119] Here, the number N of damping pulses is equal to 2,5.

[0120] More generally, the number of damping pulses transmitted is preferably up to 3. When the driver is in differential AND mode such as illustrated in figure 7, the possible number of damping pulses is 0, 0,5, 1,5 and 2,5.

[0121] The half pulses come from the fact that both drivers have to park in the same state as the differential mode requires.

[0122] If fully differential AND mode is used the possible number of pulses are 0, 1, 2 or 3. Again, this difference comes from the nature of differential state and fully differential state.

[0123] In the present example, the first damping pulse (in full line) is referenced DP1, the second damping pulse (in dotted line) is referenced DP2 and the last half damping pulse (in full line) is referenced DP3.

[0124] The power setting for the first damping pulse DP1 is Damp1, the power setting for the second damping pulse is Damp2 and the power setting for the last half pulse is Damp3.

[0125] The number of damp settings Dampi is in fact preferably one higher that the number of damping pulses in order to have more flexibility.

[0126] It is also possible, as illustrated in this example to adjust the timing of the power setting Damp0 so that it can affect the first damp pulse DP1 leading thus to having Damp3 redundant.

[0127] It is also possible to reduce the power of the last half of the last transmitted pulse TXPL by using Damp0 instead of PWS.

[0128] We refer now more particularly to figure 8 which illustrates diagrammatically a group ENS of elements forming in particular the active damping means ACTDM and the control means CTRML.

[0129] The first element is a digital-to-time converter based phase modulator DTCMD receiving an initial clock signal CLK0 having here a frequency equal to 54,24 MHz.

[0130] The DTC based phase modulator DTCMD is controlled by the control signal TX_MOD_SEL.

[0131] The DTC modulator DTCMD delivers two signals OUT10 and OUT20 having the frequency equal to 54,24 MHz, the phase difference between these two signals being controlled by the control signal TX_MOD_SEL.

[0132] The two signals OUT10 and OUT20 are delivered to a clock divider and +/- 180°modulator CLKDV which delivers two signals OUT1 and OUT2 having the frequency equal to the ALM frequency (here 13,56 MHz).

[0133] This element CLKDV is controlled by the control signal TX_PH_INVERT.

[0134] Of course, if the frequency of the initial clock signal CLK0 is equal to 13,56 MHz, the element CLKDV does not include a frequency divider but include nevertheless the +/-180° modulator.

[0135] And, optional mixing stage MX receives the two signals OUT1 and OUT2. This mixing stage MX is optional because it is not necessary if the antenna of the tag is a differential antenna while it is necessary if the antenna is a single ended antenna.

[0136] At last, a driving stage DRSTG is connected to the output of the mixing circuit and includes in particular the two above mentioned drivers respectively connected to the terminals TTX1 and TTX2. This driving stage DRSTG is controlled by the control signal TX_EN and delivers the two signals RFO1 and RFO2.

[0137] The control signals TX_MOD_SEL, TX_PH_INVERT and TX_EN are delivered by the processing unit MC.

[0138] Any internal conventional structure of a DTC based phase modulator may be used.

[0139] For example, the DTC based phase modulator DTCMD may include a tapped delay locked loop with 64 taps to allow 64 differential output states with 560 picosecond phase differences between them. Differential output states are achieved by using 2 taps and 64 output states are achieved by the same two outputs in reverse and non-reverse state for every combination of 2.

[0140] Every output has modulation range of 360°. Modulation is performed by switching between output taps to change clock phase by using the control word TX_MOD_SEL.

[0141] For example, the maximum value of the word TX_MOD_SEL generates OUT10 and OUT20 with angles of 0° and 360° which translates into OUT1 and OUT2 having angles of 0° and 180° which in turn gives maximum power. If the mixing stage is used, this provides full pulse with PWM.

[0142] When value of TX_MOD_SEL decreases, the angles of OUT1 and OUT2 both move towards 90°. At the minimum value 0 of the control word TX_MOD_SEL, the transmitted power is 0, and if mixing is used, the resulting pulse width is also 0.

[0143] Here, the DTC modulator DTCMD operates at 4 times the carrier frequency and therefore it has to modulate the carriers for 4 times the angle to get the proper angle after frequency division.

[0144] Thus, this outphasing operation permits to control the power of the transmitted pulses and the power of the damping pulses.

[0145] We refer now to figure 9 which illustrates diagrammatically an embodiment of a mixing circuit MX.

[0146] This mixing circuit comprises a multiplexor MUX having a first input I1, a second input 12, a third input 13 and a fourth input 14 as well as two outputs connected to the driver's stage DRSTG.

[0147] The first input and the second input I1, 12, are connected to a logical circuit LGC including a NAND gate and an OR gate.

[0148] The logical circuit LGC is intended to receive the two signals OUT1 and OUT2.

[0149] The third input 13 and the fourth input 14 of the multiplexor MUX receive directly the two signals OUT1 and OUT2.

[0150] The multiplexor MUX is controlled by a control signal TX_OUTPH_NPWM delivered by the processing unit MC.

[0151] Depending on the value of this control signal, the two outputs of the multiplexer are either connected to the logical circuit or directly to element CLKDV.

[0152] If the output of the multiplexor is connected to the first input I1 and second input 12, a radiofrequency pulse-width modulation operation is performed.

[0153] If the outputs of the multiplexor are connected to third and fourth inputs 13 and 14, no mixing operation is performed.

[0154] While the outphasing operation is advantageously used when the antenna is a differential antenna, to control the damping pulses power and also advantageously the transmitted pulses power, outphasing operation cannot be used when a single antenna is used as illustrated in figure 10. In such a configuration, the impedance matching and filtering circuit CIMPFLT2 is connected only to terminals TRX1, TRX2 and TTX1.

[0155] In such a case, the mixing circuit is actually implemented to convert the outphased carriers OUT1 and OUT2 to RF PWM signals, because the signals cannot be mixed on the antenna.

[0156] Although the active damping operation may be used standalone, it could be useful, in some applications, to combine the active damping operation with a passive damping operation by using a controllable resistive circuit CPDAMP, as illustrated in figure 11, connected to the antenna ANT of the tag and configured to perform a passive damping operation at the end of the transmitted burst in the beginning of the pause period.

[0157] Such a resistive circuit CPDAMP comprises damping resistors R_{TX1}, R_{TX2}, RTX_{DAMP1}, RDAMP2, R_{RX5} controlled by switches SW_{TX1}, SW_{TX2}, SW_{DAMP1}, SWDAMP2 and SW_{RX5}.

[0158] Those switches are connected to terminals TDDMP1, TDDMP2, TCDMP1, TCDMP2 of the transmission means TX and to the terminal TRDMP1 of the receiving means RX.

[0159] A control signal TX_CE_DAMP, delivered by the processing unit MC can activate a passive damping control means TDCM for controlling the switches.

[0160] Switches SW_{RX1} and SW_{RX2} are controlled statically by an option bit and are not changed during the duration of the TX frame.

[0161] VDC is a voltage source.

[0162] The damping circuits CPDAMP may be for example the one disclosed in EP2824612A1 mentioned above.

[0163] We refer now more particularly to figure 12 to explain how the lookup table LUT containing reference values can be determined.

[0164] In fact, the wireless transponder TG is of a given model of wireless transponder, i.e. belongs to a family of transponders having the same characteristics, in particular concerning the antenna and the matching and filtering circuit.

[0165] The reference values of the transmitted pulses power, the reference values of the additional or damping pulses power as well as the number of damping pulses are determined for the referenced tag TGREF during a development phase of this referenced tag. And the reference values as well as the number N is determined for each reference distance DREFj of a set DREFS of reference distances DREF1-DRFP by using a performance criterion CRT.

[0166] More precisely, for example, the performance criterion is the phase drift of the phase locked loop (PLL) of the reference tag from the initial phase.

[0167] As a matter of fact, before the tag starts active mode modulation, it has to lock its PLL to the phase of the received signal.

[0168] And once the tag starts transmitting, the received signal is corrupted by transmitting signal. In order to mitigate this issue, damping is used. The effectiveness of damping is determined by how clearly the reader signal phase can be determined during transmission.

[0169] Because damping is not ideal, there will be some phase drift of the PLL during transmission of a whole frame.

[0170] The amplitude of this phase drift is the criterion.

[0171] More precisely, for each reference distance DREFj, the power setting PWS, the power setting Dampi and the number N of damping pulses are determined so that the amplitude of this phase drift DRFF during transmission of a whole frame is as low as possible, and practically smaller than a threshold TH, which can be equal for example to 20°.

[0172] In other words, in this non limitative example, the power setting PWS, the power setting Dampi and the number N of damping pulses are determined so that the amplitude of this phase drift DRFF is smaller than 20° during the transmission of the whole frame.

[0173] Thus, reference value PWS DAMPi and N can be determined and associated to the reference distance DREFj.

[0174] The invention is not limited to the above disclosed embodiments.

[0175] Thus in an alternative implementation, a simple phase modulator can be used, capable of only +/- 180° changes, in conjunction with an envelope shape control such as the one disclosed in EP3761581, to control the power output during the damping operation.

Claims

1. Method for managing a signal transmission emitted by a wireless transponder (TG) to a reader (RD), said transmission using an active load modulation and being based on transmitted bursts (TXBST) separated by pause periods (PP), each transmitted burst (TXBST) including transmitted pulses (TXP), said method comprising

- performing an active damping operation (ST64) at the end of said transmitted bursts in the beginning of the pause periods, said active damping operation comprising transmitting a number of additional pulses (DP1, DP2, DP3) having a phase opposite to the phase of said transmitted pulses (TXP), and
- controlling the transmitted pulses power (PWS), the additional pulses power (Dampi), the number of additional pulses (N) based on a distance (D) between the reader and the wireless transponder and on reference values of the transmitted pulses power, the additional pulses power, and the number respectively associated with reference distances (DREF1-DREFP).

2. Method according to claim 1, wherein the number (N) of additional pulses is equal or smaller than three.

3. Method according to claim 1 or 2, wherein controlling the transmitted pulses power, the additional pulses power, the number of additional pulses comprises determining said distance (D) and selecting the reference values associated to the closest reference distance (DREFj) to the determined distance.

4. Method according to any one of the preceding claims, wherein said wireless transponder is of a given model of wireless transponder, and the method further comprises elaborating said reference values of the transmitted pulses power, the additional pulses power and the number of additional pulses for a reference wireless transponder (TGREF) of said given model during a development phase of said reference wireless transponder, said elaborating comprising determining said reference values for each reference distance of a set of references distances by using a performance criterion (CRT).

5. Method according to claim 4, wherein for a given reference distance, determining the associated reference values comprises selecting the reference values leading to the fulfilment of the performance criterion (CRT).

6. Method according to claim 5, wherein the reference wireless transponder has a phase locked loop, the signal transmission includes frames transmission and the fulfilment of the performance criterion (CRT) comprises an amplitude of the phase drift (DRFF) of the phase locked loop with respect to a its initial phase during the transmission of a whole frame, being smaller than a threshold (TH).

7. Method according to any one of the preceding claims, wherein controlling the transmitted pulses power, the additional pulses power comprising performing an outphasing of two-phase modulated signals.

8. Method according to claim 7, wherein controlling the transmitted pulses power, the additional pulses power further comprises performing a mixing operation of both outphased signals (out1, out2) to obtain pulse width modulated signals.

9. Method according to any one of the preceding claims, further comprising performing a passive damping operation (ST65) at the end of said transmitted bursts in the beginning of the pause periods, said passive damping operation comprising activating a connection of at least a resistive circuit to the antenna of the wireless transponder.

10. Wireless transponder, comprising transmission means (TX) configured to transmit an active load modulated signal to a reader, said modulated signal including transmitted bursts separated by pause periods, each transmitted burst including transmitted pulses, active damping means configured to transmit at the end of said transmitted bursts in the beginning of the pause periods, a number of additional pulses having a phase opposite to the phase of said transmitted pulses, and control means (CTRLM) configured to control the transmitted pulses power, the additional pulses power, the number of additional pulses based on a distance between the reader and the wireless transponder and on reference values of the transmitted pulses power, the additional pulses power, and the number respectively associated with reference distances.

11. Wireless transponder according to claim 10, wherein the number (N) of additional pulses is equal or smaller than three.

12. Wireless transponder according to claim 10 or 11, further comprising measurement means (MMS) configured to determine the distance between the wireless transponder and the reader, and wherein the control means (CTRLM) are configured to control the transmitted pulses power, the additional pulses power, the number of additional pulses, by selecting for the determined distance, the reference values associated to the closest reference distance to the determined distance.

13. Wireless transponder according to claim 9 or 10, wherein said wireless transponder is of a given model of wireless transponder, and the reference values of the transmitted pulses power, the additional pulses power for a reference wireless transponder (TGREF) of said given model are elaborated during a development phase of said reference wireless transponder, for each reference distance of a set of references distances by using the fulfilment of a performance criterion.

14. Wireless transponder according to claim 13, the reference wireless transponder has a phase locked loop, and the fulfilment of the performance criterion comprises an amplitude of the phase drift (DRFF) of the phase locked loop with respect to its initial phase during the transmission of a whole frame, being smaller than a threshold (TH).

15. Wireless transponder according to any one of the claims 10 to 14, wherein the control means comprises a digital-to-time converter based phase modulator (DTCMD) configured to control the transmitted pulses power, the additional pulses power by performing an outphasing of two phase modulated signals.

16. Wireless transponder according to claim 15, wherein the control means further comprises a mixer circuit (MX) configured to perform a mixing operation of both outphased signals to obtain pulse width modulated signals.

17. Wireless transponder according to any one of the claims 10 to 16, further comprising a controllable resistive circuit (CPDAMP) connected to the antenna of the wireless transponder and configured to perform a passive damping operation at the end of said transmitted bursts in the beginning of the pause periods.

18. Wireless transponder according to any one of the claims 10 to 17, configured to perform wireless communications according to at least one of the following standards: ISO14443 TypeA; ISO14443 TypeB; ISoO15693.

FIG.1

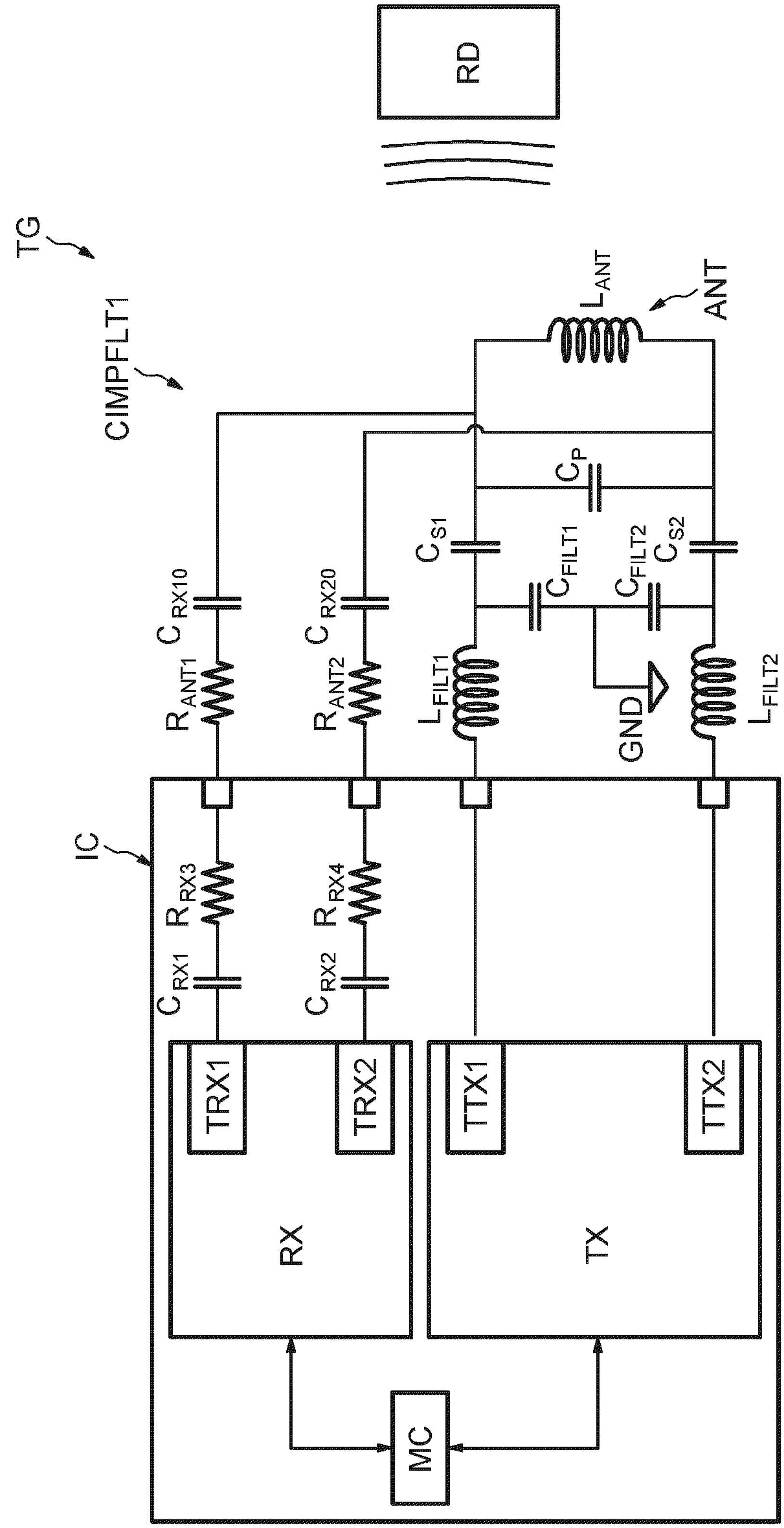

TG
CIMPFLT1
RD
ANT
L_{ANT}
C_P
C_{S1}
C_{S2}
C_{FILT1}
C_{FILT2}
C_{RX10}
C_{RX20}
R_{ANT1}
R_{ANT2}
L_{FILT1}
L_{FILT2}
GND
IC
R_{RX3}
R_{RX4}
C_{RX1}
C_{RX2}
TRX1
TRX2
TTX1
TTX2
RX
TX
MC

FIG.2

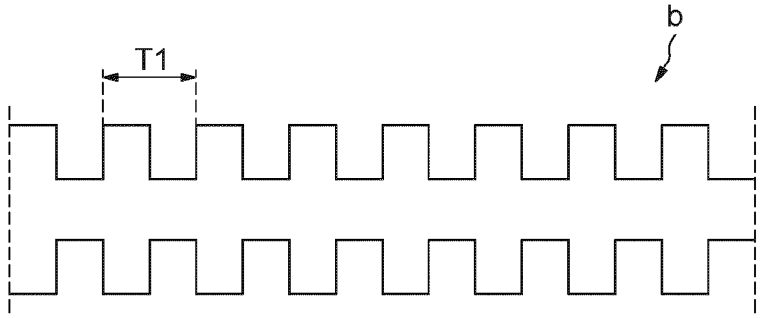


FIG.3

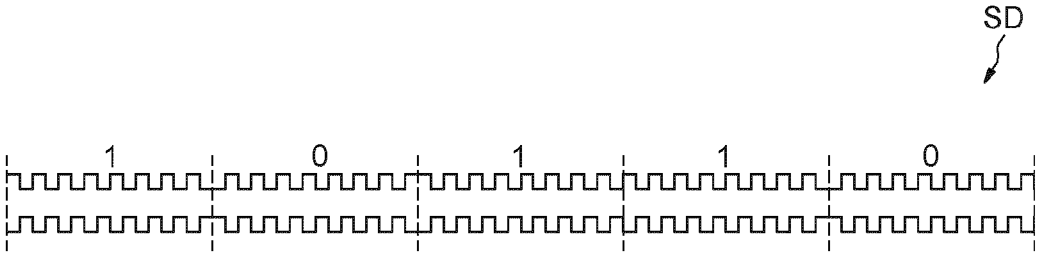


FIG.4

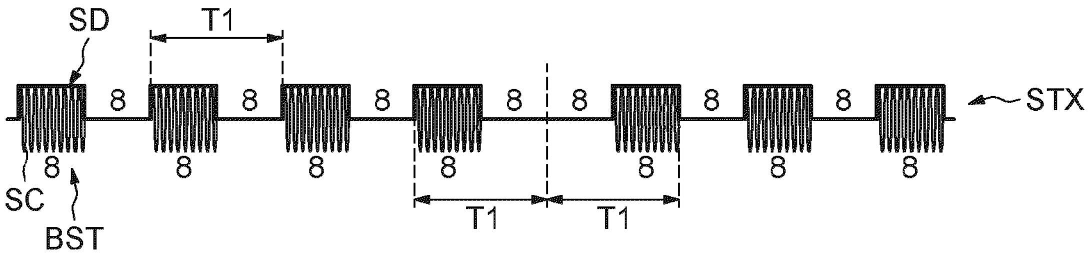


FIG.5

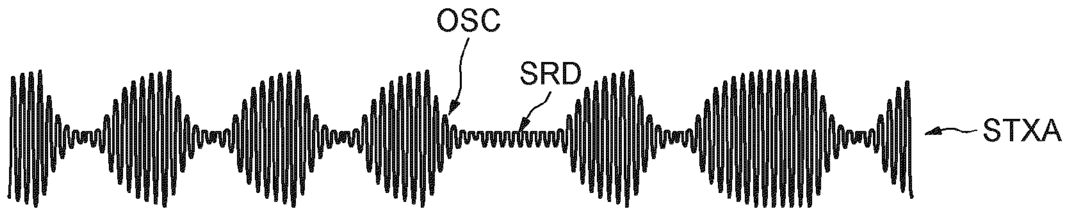


FIG.6

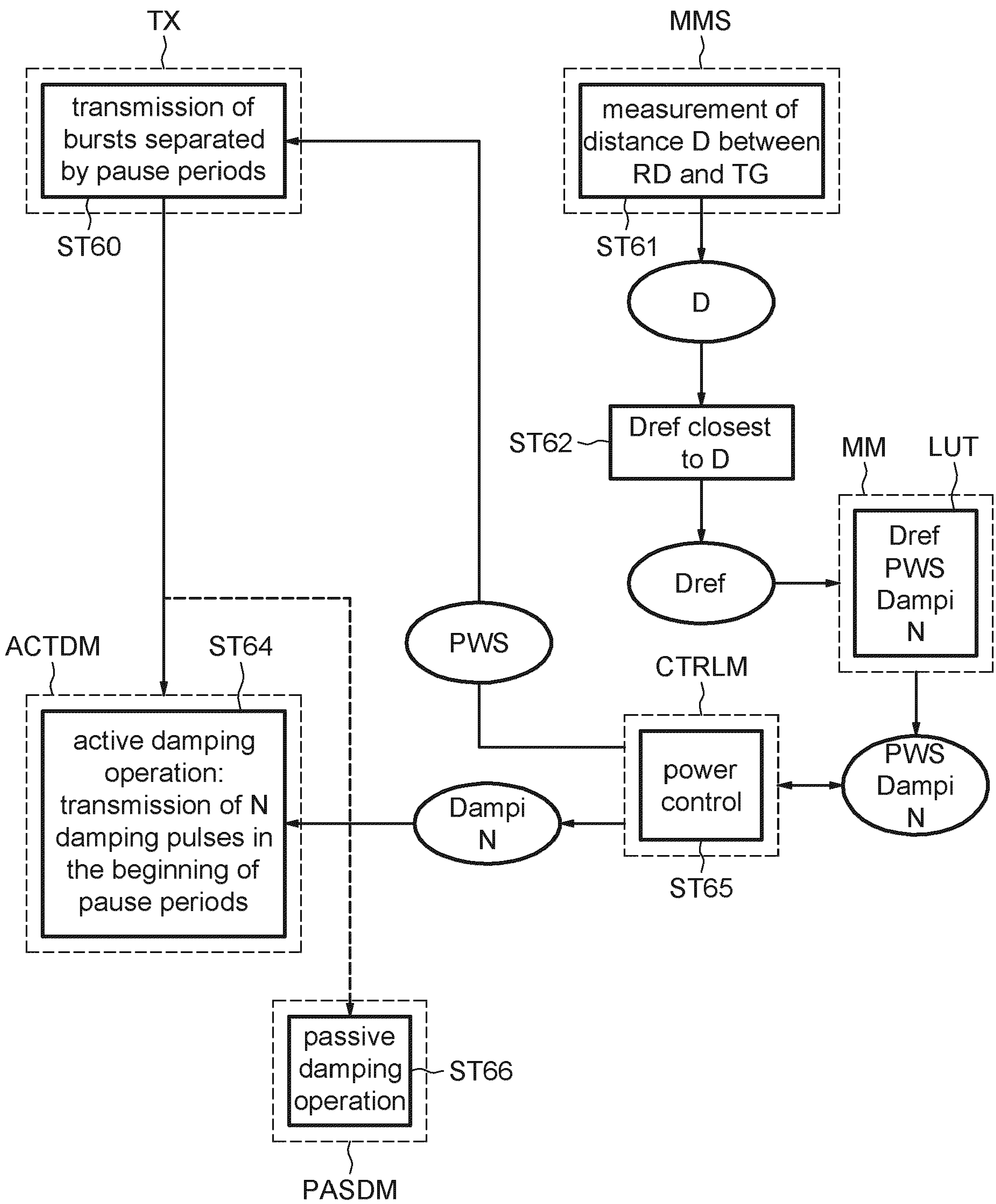

TX
transmission of bursts separated by pause periods
ST60
MMS
measurement of distance D between RD and TG
ST61
D
ST62
Dref closest to D
MM
LUT
Dref
Dref PWS Dampi N
PWS
ACTDM
ST64
CTRLM
active damping operation: transmission of N damping pulses in the beginning of pause periods
Dampi N
power control
PWS Dampi N
ST65
passive damping operation
ST66
PASDM

FIG.7

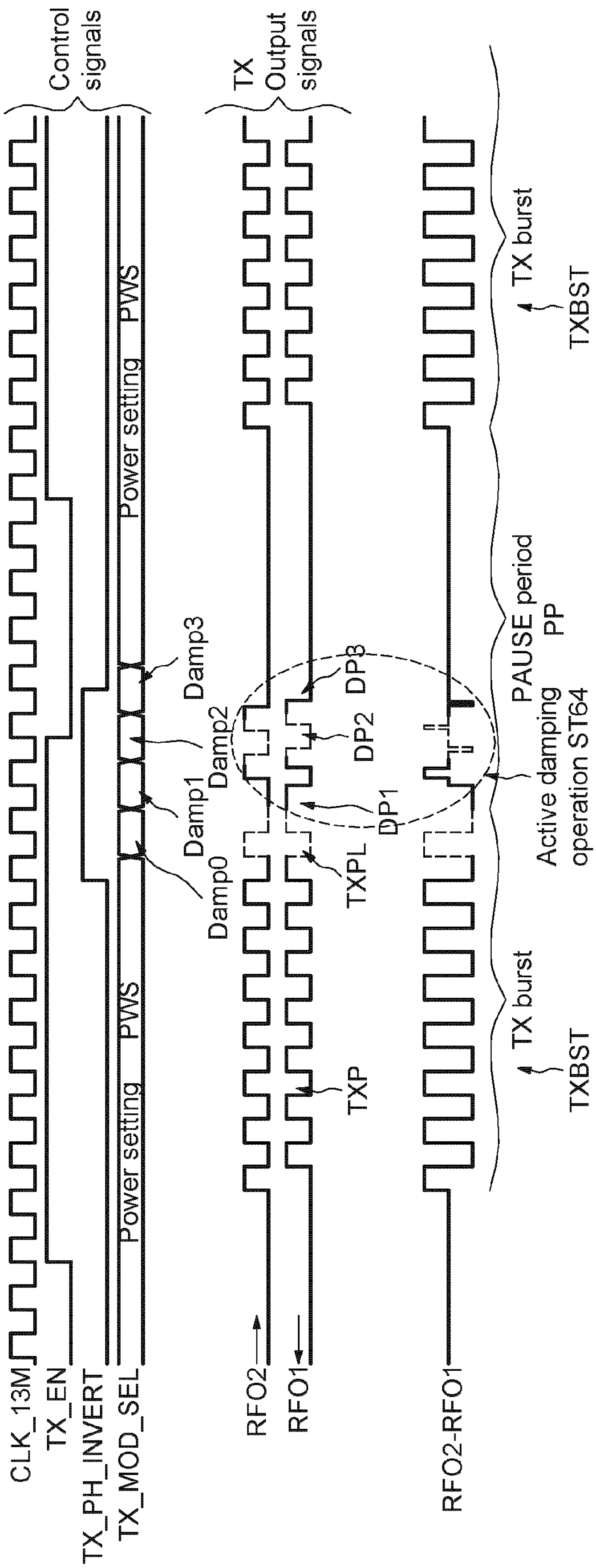

Control signals
CLK_13M
TX_EN
TX_PH_INVERT
TX_MOD_SEL
Power setting PWS
Power setting PWS
Damp0
Damp1
Damp2
Damp3
TX Output signals
RFO2
RFO1
TXP
TXPL
DP1
DP2
DP3
RFO2-RFO1
TXBST
TX burst
TXBST
TX burst
Active damping operation ST64
PAUSE period PP

FIG.8

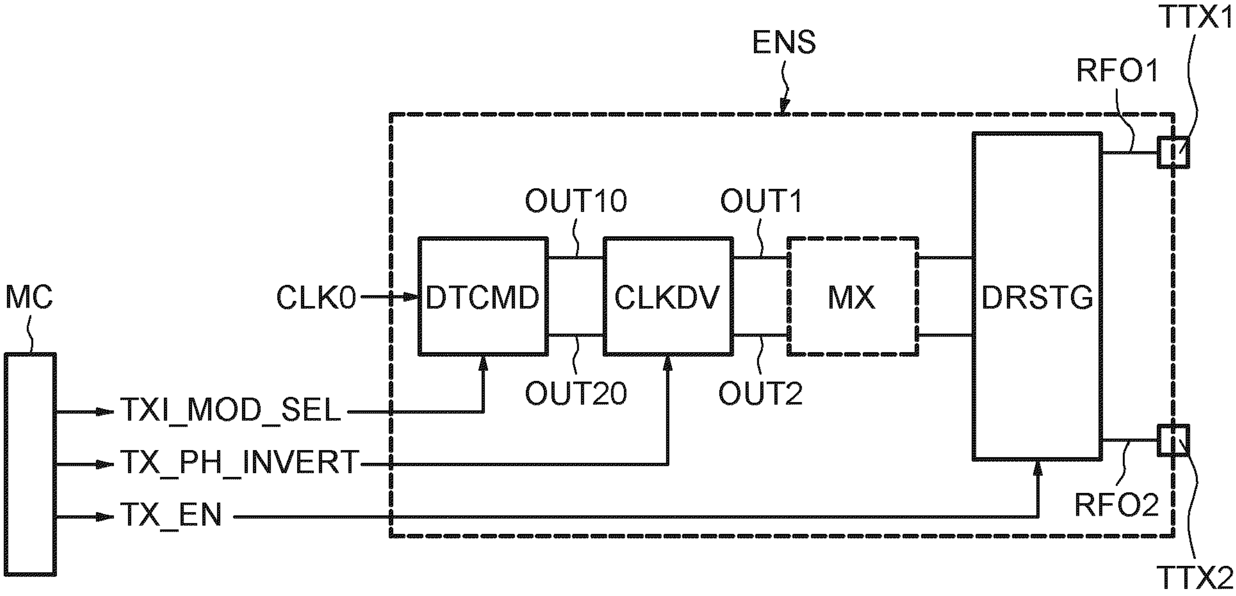

ENS
TTX1
RFO1
OUT10
OUT1
MC
CLK0
DTCMD
CLKDV
MX
DRSTG
OUT20
OUT2
TXI_MOD_SEL
TX_PH_INVERT
TX_EN
RFO2
TTX2

FIG.9

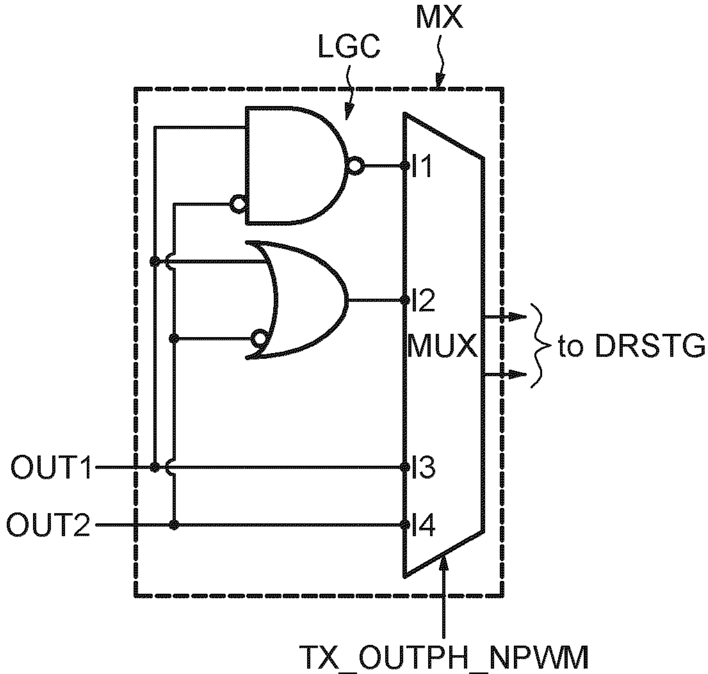
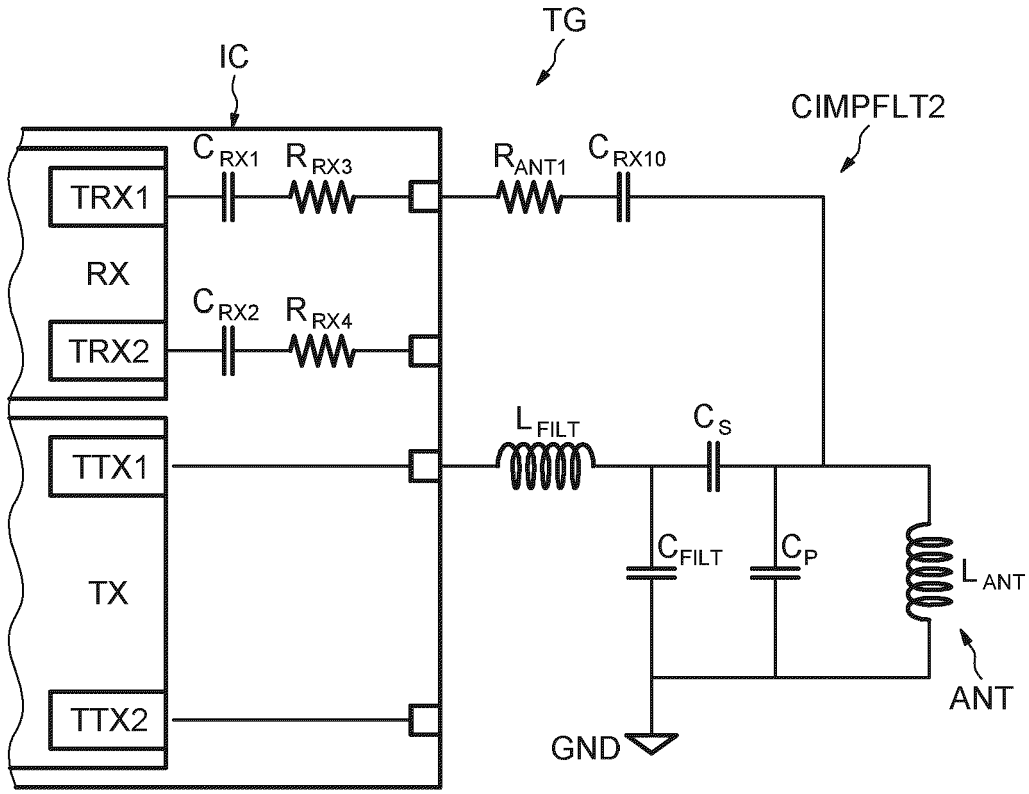

MX
LGC
I1
I2
MUX
to DRSTG
OUT1
I3
OUT2
I4
TX_OUTPH_NPWM

FIG.10


TG
IC
CIMPFLT2
C RX1
R RX3
R ANT1
C RX10
TRX1
RX
C RX2
R RX4
TRX2
L FILT
C S
TTX1
C FILT
C P
L ANT
TX
ANT
TTX2
GND

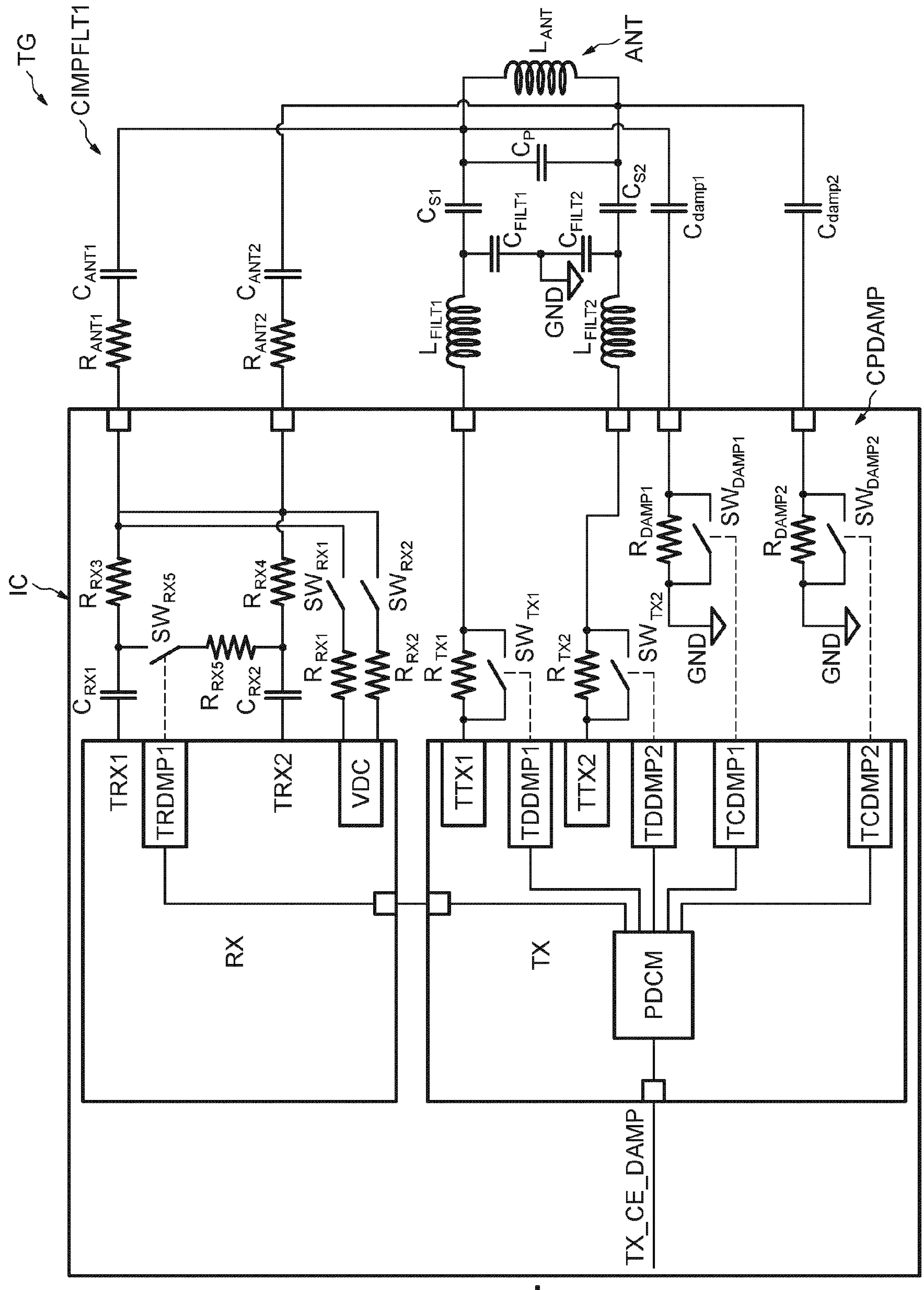
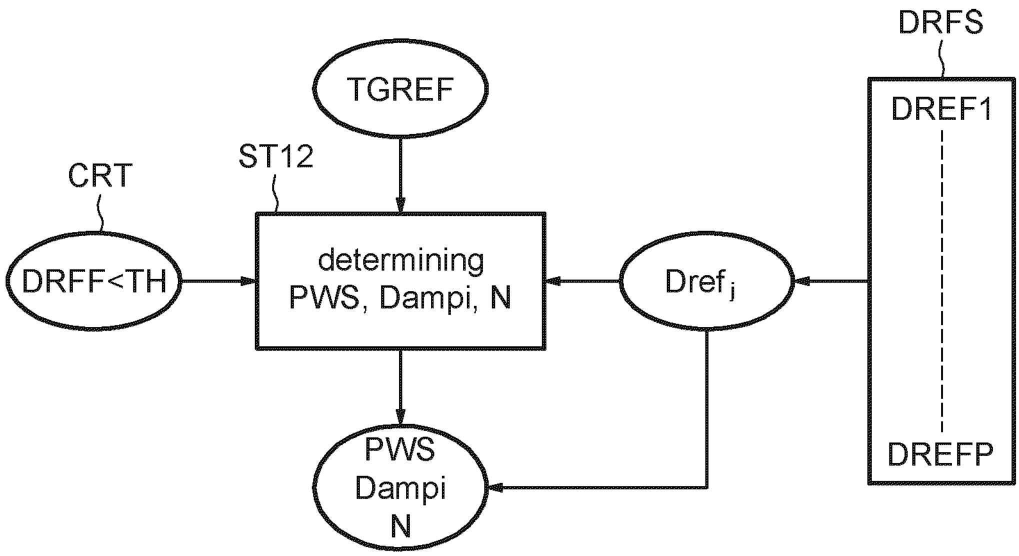

TG
CIMPFLT1
IC
CPDAMP
ANT
L_{ANT}
C_P
C_{S1}
C_{S2}
C_{FILT1}
C_{FILT2}
C_{damp1}
C_{damp2}
C_{ANT1}
C_{ANT2}
R_{ANT1}
R_{ANT2}
L_{FILT1}
L_{FILT2}
GND
R_{RX3}
R_{RX4}
SW_{RX5}
R_{RX5}
SW_{RX1}
SW_{RX2}
C_{RX1}
C_{RX2}
R_{RX1}
R_{RX2}
R_{TX1}
SW_{TX1}
R_{TX2}
SW_{TX2}
R_{DAMP1}
SW_{DAMP1}
R_{DAMP2}
SW_{DAMP2}
TRX1
TRDMP1
TRX2
VDC
RX
TTX1
TDDMP1
TTX2
TDDMP2
TCDMP1
TCDMP2
TX
PDCM
TX_CE_DAMP

FIG.11

FIG.12


DRFS
TGREF
DREF1
CRT
ST12
DRFF<TH
determining
PWS, Dampi, N
Dref j
PWS
Dampi
N
DREFP

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 22 17 0024

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 3 512 107 A1 (NXP BV [NL]) 17 July 2019 (2019-07-17) * paragraphs [0027], [0031] - [0033]; figures 5A, 5B * * paragraphs [0041] - [0043]; figure 7 * -----	1-18	INV. H04B5/00
A	US 2013/003712 A1 (KUNC VINKO [SI] ET AL) 3 January 2013 (2013-01-03) * paragraphs 16,23-25,40-42 - pages 5,6,7 * -----	1-18	
A	EP 3 399 655 A1 (STMICROELECTRONICS RAZVOJ POLPREVODNIKOV D O O [SI]) 7 November 2018 (2018-11-07) * paragraphs [0025], [0028] - [0030], [0060] - [0062]; figure 5 * -----	1-18	

TECHNICAL FIELDS SEARCHED (IPC)
H04B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	13 October 2022	De Vries, Jane

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 22 17 0024

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

13-10-2022

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 3512107 A1	17-07-2019	CN 110034778 A	19-07-2019
		EP 3512107 A1	17-07-2019
		US 2019215203 A1	11-07-2019
US 2013003712 A1	03-01-2013	CN 104303427 A	21-01-2015
		EP 2727255 A1	07-05-2014
		SI 23786 A	31-12-2012
		US 2013003712 A1	03-01-2013
		WO 2013002736 A1	03-01-2013
EP 3399655 A1	07-11-2018	CN 108809360 A	13-11-2018
		CN 208283955 U	25-12-2018
		EP 3399655 A1	07-11-2018
		US 10122557 B1	06-11-2018
		US 2019044770 A1	07-02-2019

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO 2013002736 A1 **[0008]**
- EP 2824612 A1 **[0008] [0017] [0105] [0162]**
- EP 3145092 A1 **[0105]**
- US 10608705 B2 **[0105]**
- EP 3761581 A **[0175]**